Chapter 14
Adaptation Processes in Agriculture and Food Security: Insights from Evaluating Behavioral Changes in West Africa

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Abstract This chapter focuses on the evaluation of adaptive capacities of community-level human systems related to agriculture and food security. It highlights findings regarding approaches and domains to monitor and evaluate behavioral changes from CGIAR's research program on climate change, agriculture and food security (CCAFS). This program, implemented in five West African countries, is intended to enhance adaptive capacities in agriculture management of natural resources and food systems. In support of participatory action research on climate-smart agriculture, a monitoring and evaluation plan was designed with the participation of all stakeholders to track changes in behavior of the participating community members. Individuals' and groups' stories of changes were collected using most significant change tools. The collected stories of changes were substantiated through field visits and triangulation techniques. Frequencies of the occurrence of characteristics of behavioral changes in the stories were estimated. The results show that smallholder farmers in the intervention areas adopted various characteristics of

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behavior change grouped into five domains: knowledge, practices, access to assets, partnership and organization. These characteristics can help efforts to construct quantitative indicators of climate change adaptation at local level. Further, the results suggest that application of behavioral change theories can facilitate the development of climate change adaptation indicators that are complementary to indicators of development outcomes. We conclude that collecting stories on behavioral changes can contribute to biophysical adaptation monitoring and evaluation.

Keywords Behavioral changes • Climate change • Monitoring • Evaluation

14.1 Introduction

Adaptation to climate change refers to adjustments of physical, ecological and human systems that increase societies' abilities to cope with the change (see Box 14.1). This may involve any adjustment to the physical systems, social or environmental processes, or perceptions of climate risk, practices and functions that reduce risks and increase exploitation of new (or previously overlooked) opportunities. Agriculture is particularly sensitive, because it will be significantly affected by climate change through effects on water availability, temperatures, soil processes, pests, pathogens and competitors, which in turn will influence crop productivity at farm level (Turral et al. 2011).

Box 14.1: Adaptation, Adaptive Capacity and Food Security

Adaptation is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2014b).

Adaptive capacity is the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences of climate change (IPCC 2014b).

Food security exists when all people at all times have physical or economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO 2008).

At the center of climate change adaptation efforts are interventions intended to boost adaptive capacity and/or stimulate adaptive action (Pringle 2011). Fortunately, there are several categories of adaptive options in agriculture, including: technological developments, government programs, insurance, and modifications of farm production and/or financial management practices (Smit and Skinner 2002). Nevertheless, to date agricultural adaptation initiatives have mainly focused on mitigating risks to crop productivity associated with changing climatic conditions. Furthermore, links between climate change and food productivity have been largely

explored by analyzing the relationships between climatic and agricultural variables (Di Falco et al. 2011).

In practice, continued refinement of soil, water, tree and crop management practices will contribute much of the required adaptation, except in systems that are already water stressed (Turral et al. 2011). However, while it is globally acknowledged that food productivity contributes to food security, post-harvest processes are also important. Furthermore, since their own agricultural activities are the primary sources of food for many people in developing countries, effects of climatic changes on crop productivity (and the people's responses to them) will strongly influence their overall food security (Ingram et al. 2008). Hence, efforts to ensure food security must include strengthening of the adaptive capacity (Plummer and Armitage 2010) of individuals, households and communities by improving their access to, knowledge of, and control over natural, human, social, physical and financial resources (Pramova and Locatelli 2013). For these reasons, several authors (Pittock and Jones 2000; Stafford Smith et al. 2011) have argued that adaptation to climate change needs to be seen as an iterative process. If so, monitoring and evaluation (M&E) of adaptation and/or progress towards it are clearly important to assess the effectiveness of adaptation interventions, options and technologies (UNFCCC 2010).

However, there are uncertainties regarding appropriate adaptation indicators. Ideally, they should be different but complementary to development variables, but current approaches to adaptation M&E do not take this distinction into account. This chapter describes efforts to improve the design and implementation of adaptation M&E, at program and project levels, undertaken in a CGIAR Research Program (CRP7). Specific objectives were: (i) to demonstrate the applicability and utility of the theory of planned behavioral changes for adaptation M&E, focusing on adaptive capacity, and (ii) contribute to the development of an integrated biophysical-behavioral changes approach to adaptation M&E.

14.2 Approach

14.2.1 The Intervention

The efforts to improve adaptation M&E reported here were part of the Consultative Group on International Agricultural Research (CGIAR) Research Program CRP7, on climate change, agriculture and food security (CCAFS), a strategic collaboration between CGIAR and the Earth System Science Partnership (ESSP). The overarching objectives of CRP7 are: (1) to identify and test pro-poor adaptation and mitigation practices, technologies and policies for enhancing food systems, adaptive capacity and rural livelihoods; and (2) to provide diagnosis and analysis that will ensure cost-effective investments, the inclusion of agriculture in climate change policies, and the inclusion of climate issues in agricultural policies, from

the sub-national to the global level in ways that benefit the rural poor (CGIAR 2011).

The program encompasses four research themes, being addressed from 2011 to 2015, designed to enhance adaptive capacity in agricultural, natural resources management and food systems, thereby leading to improvements in environmental health, rural livelihoods and food security through diverse trade-offs and synergies. The four themes are: (i) adaptation to progressive climate change, (ii) adaptation through managing climate risk, (iii) pro-poor climate change mitigation, and (iv) integration of decision-making processes.

Research and development activities under this CCAFS program were place-based and undertaken at several spatial levels within so-called "target regions". West Africa region was one of the places where the research and development activities were undertaken in five countries: Burkina Faso, Ghana, Mali, Niger and Senegal. A participatory action research (PAR) approach (led by the International Center for Research in Agroforestry, ICRAF, in collaboration with the five countries' national agricultural research systems) was used to promote agricultural technologies (assisted natural regeneration, composting, tree planting, etc.), practices, policies and capacity enhancement (on-farm application trainings) for adaptation to progressive climate change. The participatory action research has contributed to the CCAFS's planned 5-year output, as stated in the Research Proposal (CGIAR Research Program 7 2011; output 1.1.1): "*Development of farming systems and production technologies adapted to climate change conditions in time and space through design of tools for improving crops, livestock, and agronomic and natural resource management practices.*"

Parallel to this participatory action research on adaptation, a capacity enhancement action on planning, monitoring and evaluation of climate change adaptation (led by the International Union for the Conservation of Nature, IUCN, in collaboration with the five national agricultural research systems) was conducted. Thus, prior to the development of the M&E plan, vulnerability assessments were conducted and adaptation actions planned in a participatory action research framework (Somda et al. 2014). Four of the five West African countries (Burkina Faso, Ghana, Niger and Senegal) were involved in the participatory action research of the CGIAR's CCAFS program.

14.2.2 The Monitoring and Evaluation Approach and Technique

The framework for monitoring and evaluating adaptive capacity was developed based on the theory of planned behavior (TPB) by Ajzen (1991), which proposes a model that can help efforts to measure the effectiveness of interventions designed to guide human actions. It has been applied to adaptation M&E because adaptation requires technological and/or behavioral changes that are consistent with the

sustainable livelihood framework (IPCC 2014a). Hence, climate change adaptation interventions are designed not only to implement adaptation actions, but also to change behavior at individual, household, community, country and international levels. The TPB holds behavior to be an outcome of competing influences balanced and decided upon by the individual. Direct influences are the behavioral intentions, which are also influenced by attitudes towards the interventions, subjective norms and perceived behavioral control. It should be noted that the TPB helps efforts to identify cognitive targets for change, rather than offering suggestions on how these cognitions might be changed (Hardeman et al. 2002; Morris et al. 2012).

In this project, researchers, governments and NGOs' extension officers and stakeholder communities' members were convened in workshops to plan the adaptation M&E, with the intention to use the most significant change technique. These workshops allowed stakeholders in each country to discuss various domains where intentional changes of behavior of participants in the planned field adaptation activities were expected, and plan M&E activities accordingly. Stakeholders in each country were asked to identify domains of their lifestyles that would change if the CCAFS program was successful. The identified domains of change were deliberately left fuzzy to allow people to have different interpretations of what constitutes a change in that area (Davies and Dart 2005). Table 14.1 summarizes the M&E plans that emerged from the countries' workshops.

The predefined domains of changes are inevitably context-specific, reflecting expectations regarding focal communities' likely changes and evolution during

Table 14.1 Summary of the adaptation monitoring and evaluation plans that emerged for each country

Key elements of M&E plans	Burkina Faso	Ghana	Niger
Intentional domains of changes	D1: Partnership	D1: Partnership	D1: Partnership
	D2: Knowledge	D2: Knowledge	D2: Knowledge
	D3: Practices	D3: Practices	D3: Food security
	D4: Organization	D4: Food security	
Behavioural changes collection methods	Focus group and Individual discussion	Focus group and Individual discussion	Focus group and Individual discussion
Types of behavioural change to collect	Individual and collective behaviours	Individual and collectives behaviours	Individual and collective behaviours
Technique for selecting most significant changes	Iterative voting	Iterative voting	Iterative voting
Number of stories of changes collected (experimental)	2 collective changes (men and women)	2 collective changes (men and women)	2 collective changes (men and women)
	34 individual changes (men and women farmers)	12 individual changes (men and women farmers)	16 individual changes (men and women farmers)

Sources: Reports from workshops on adaptation M&E in each country

adaptation-intervention cycles. However, communities in different contexts or locations may often share similar domains of change. Hence, using predetermined domains of change should be considered advisable rather than compulsory. Furthermore, changes that have occurred outside predefined domains should also be collected (i.e. identified and characterized) for learning purposes in order to improve future adaptation action M&E.

Purposive sampling was then used to collect individual level stories of changes through interviews. The sample size for individual interviews was kept small for experimental reasons. Purposive sampling was preferred to random sampling because the ultimate objective of our adaptation M&E was to learn from stories of changes, and ultimately move agricultural extension practices more towards success and away from failure. However, to improve the validity and reliability of the purposive sampling, discussions were conducted to collect stories of changes of male and female groups of farmers.

The most significant change technique (Davies and Dart 2005) was used to collect stories of changes of both individual farmers and gender-based groups. The technique is not based on predefined performance indicators, but on "field-based stories" that give meaning to people's reality and effects of projects on that reality. It allows the story tellers (individuals or groups) to describe what has happened in their lives and practices (particularly, in this project, the way they farm) in conjunction with the participatory action research adaptation action. Scientists from the respective countries' national agricultural research systems collected the stories of change.

The collected significant stories were subjected to participatory processing, in which characteristics of behavior changes in the stories were counted, and then the most significant changes were selected, substantiated and validated. To select the most significant changes participants read the stories one by one and discussed the characteristics of changes described by the individuals or gender-based groups. The substantiation involved field visits and triangulation processes including discussion with resource persons and groups in the communities to ascertain whether behavioral changes noted in the stories had effectively occurred. Such substantiation has two objectives: (i) to verify the effectiveness of the occurrence of the change characteristics with the story tellers, other community members and fieldworkers who have worked with the selected communities, (ii) to gather additional data to complement information obtained during the story collection step.

The characteristics of behavior changes were counted by extracting all identified characteristics in the collected stories, then calculating their frequencies of occurrence, in terms of the percentages of people whose stories included them. This also allowed the identification of domains of life where changes had been induced in the selected communities by the participatory action research of the CCAFS program. In this chapter we have chosen to present frequencies of occurrence of behavioral change characteristics, but not the selection and substantiation results (which can be obtained from the authors on request).

14.3 Analysis

14.3.1 Consistency Between Planned Behavioral Theory and the CCAFS Program's Objectives

The plans developed for adaptation M&E suggested that involving farmers at the onset would help to clarify the domains of life that adaptation activities can influence. It allowed researchers to become aware of aspects of the beneficiaries' lifestyle that the technology and training activities they offered were likely to change. This is often lacking in traditional adaptation M&E, which is usually based on biophysical performance indicators. Thus, pre-identifying domains of behavioral change has added value to the quantitative biophysical performance indicators. The results clearly showed that if the CCAFS program resulted in successful adaptation of farming systems and production technologies to changing climatic conditions, farmers would put in place changes in domains including partnership, knowledge, practices, organization, and food security. This was consistent with expectations as adaptation is a process, and the development of adapted farming systems and production technologies requires communities' members to continuously improve knowledge, work in partnership and an organized manner, adopt new practices and (thus) enhance their food security.

14.3.2 Identified Behavioral Changes Induced by the CCAFS Program in West Africa

In line with the theory of planned behavior, outcomes were defined following Earl et al. (2001), as changes in the behavior, relationships, activities, or actions of the people, groups, and organizations with whom the CCAFS program directly engages. In West Africa, the CGIAR's program for climate change, agriculture and food security works through national agricultural research systems to help farmers develop climate-smart farming systems, through participatory vulnerability assessment and adaptation planning, on-farm trials, training, monitoring and evaluation. The results of behavioral changes M&E presented here can be seen as early or short-term outcomes of the program (or outcomes to which it has contributed). Table 14.2 summarizes the characteristics of behavioral changes extracted from the stories of changes gathered in 2013.

These findings show that both men and women farmers have put in place initial changes in knowledge, agricultural practices, organization, partnership, access to productive assets and food security. Analysis of the collected stories of changes identified a domain of change that was not included in the set identified in the planning stage. This was access to productive resources, in Burkina Faso and Niger, where the CCAFS's adaptation activities have contributed to improve access to on-farm and medicinal trees for both men and women. Further the results show that

Table 14.2 Characteristics of behavioral changes identified in individual farmers' stories (% of respondents)

	Burkina Faso		Ghana		Niger	
Domains of changes/characteristics	Men	Women	Men	Women	Men	Women
1. Changes in knowledge						
Knowledge about agricultural techniques (relationships between climate change and improved varieties, plowing flat and row planting, compost preparation, etc.)	84.21	60.00	100	100	100	100
Knowledge about implementing on-farm assisted natural regeneration techniques	57.89	46.67	[a]	[a]	100	100
Knowledge of trees (planting and utilization)	36.84	62.50	33.33	33.33	10	16.67
2. Changes in agricultural practices						
Agricultural practices (use of improved seeds, row planting, compost application, fertilizer use, etc.)	57.89	73.33	100	100	100	83.33
Practicing on-farm assisted natural regeneration of trees (associated with anti-erosion sites)	5.26	13.33	33.33	33.33	100	83.33
Planting trees	26.32	40.00	[a]	[a]	[a]	[a]
3. Organizational changes						
Relationships among farmers	36.84	6.67	16.67	16.67	[a]	[a]
4. Changes in partnering	57.89	66.67	66.67	66.67	60.00	33.33
In-community collaboration (exchange of information, services and goods)	57.89	66.67	66.67	66.67	60.00	33.33
5. Access to productive resources (on-farm trees, etc.)						
Access to on-farm and medicinal trees	31.58	80.00	[a]	[a]	[a]	16.67
6. Changes in food security						
Diversity of diets and early harvests from early maturing crops	[a]	13.33	50.00	[a]	[a]	83.33
Total surveyed sample	**19**	**15**	**6**	**6**	**10**	**6**

Source: Authors' counts from the stories of changes (2013)
[a]Indicates that the characteristic was not found in the significant change stories told by farmers

involving men and women in the process of developing climate-smart agriculture has changed attitudes of both men and women to on-farm tree planting and management. Similar changes were mentioned in the Ghanaian women's group discussions (not reported in detail here). For example, a group of women of the Doggoh community in Ghana said they did not know before that women can plant trees, as they had not seen any women in the community doing it before the CCAFS program's intervention. This had restricted the access of women in most rural

communities to on-farm trees for their own purposes until their attitudinal change towards such trees.

The results also suggest that in the adaptation process farmers exhibit different stages of behavioral chances in various livelihood domains. For example, in rural communities in Burkina Faso, 84 % and 58 % of the story-tellers respectively expressed changes in knowledge of agricultural techniques and practicing improved agricultural techniques. In the Doggoh community in Ghana, none of the interviewed farmers expressed changes in knowledge about implementing assisted natural regeneration techniques, but 33 % of interviewed women and men farmers revealed changes in applying on-farm assisted natural regeneration. These differences reflect the likelihood that farmers in a community will be in different stages of behavioral changes in early parts of adaptation initiatives such as the CCAFS program.

Finally, some characteristics of changes were not identified in the individual stories of changes. This should not necessarily be interpreted as an absence of such changes, because the M&E questions only asked the farmers to report the significant changes they had experienced through participation in the CCAFS program's adaptation activities. Thus, they may have considered some changes too insignificant to describe in their stories of change.

Overall, the results indicate that participating farmers have initiated behavioral changes in various domains. Furthermore, the application of planned behavior theory allowed identification of the initiation of behavioral change at both individual and group levels in communities participating in the intervention in all three countries. Thus, the applied technique has clear potential utility for monitoring the implementation of farming systems and production technologies adapted to climate change, the spatial and temporal dissemination of adaptations, and the sustained changes in people's livelihoods and lifestyles that may be required to reduce vulnerability to its impacts.

These results are consistent with findings of innovative adoption studies, unsurprisingly as changes in behavior represent adoption of new behaviors and/or innovative practices, which is one of the most frequently advocated strategies for adapting agriculture to climate change. It should be noted that numerous variables will influence results of initiatives to foster changes. Notably, Rogers (1983) reported that factors such as attitudes, values, motivations, and perceptions of risk differ between decision-makers (producers) who are 'innovators' and those who are 'laggards' with respect to the adoption of particular innovations. In addition, according to Rothman (2000), individual or group decisions regarding behavioral initiation depend on people holding favorable expectations of the future outcome of the new pattern of behavior. However, maintenance of these new behavior patterns will mostly depend on farmers' satisfaction with the outcome they obtain (Rothman 2000).

14.3.3 Learning Opportunities from Applying Behavioral Changes Theory in Adaption Processes

Application of the theory of planned behavior has valuable potential to complement and extend the monitoring and evaluation of biophysical changes (the foci of previous agriculture and food security adaptation efforts). Three major learning opportunities can be identified from its use to monitor and evaluate adaptation processes reported here. As outlined below, the interviewees' stories of changes provided evidence of: (i) behavioral changes induced by adaptation activities; (ii) a need to maintain new patterns of behaviors and (iii) possibilities to identify adaptation-based metrics from behavioral change stories.

- ***Evidence of various new behavior patterns***: Stakeholders including researchers and extension officers from both governmental and nongovernmental organizations have learned the existence of a wide range of changes in farmers' behavior. It was particularly easy for them to identify adaptation-relevant behavior. Furthermore, the most significant change technique allowed farmers to learn how to own the adaptation process and express views about potential barriers to adaptation outcomes or maintaining initiated behavioral changes. It provided opportunities for other farmers to learn about types of changes that are occurring in their community. In this manner it can help remove barriers related to attitude, subjective norms and perceived behavioral control within farmers' communities and enhance community and other stakeholders' engagement in the CCAFS program.
- ***New behavior patterns need maintenance***: The results also suggest that initiating new behavior patterns may expose farmers to new challenges. Their stories of change provided researchers with insights into barriers related to assets and/or additional adaptive capacities after the farmers' initiation of adaptation-relevant behavioral changes. Such insight will facilitate discussion by researchers, farmers and extension officers regarding additional support farmers may require to maintain effective new behavior patterns, and avoid potential reversion to old practices that are considered inappropriate for adaptation to climate change. Furthermore, addressing the additional burdens faced by farmers after they have initiated relevant changes is important to minimize the risk of maladaptation to climate change.
- ***Developing adaptation-related metrics from behavioral change stories***: Characteristics of behavioral changes portrayed in the stories of change could be readily identified, classified, counted, and used in designing metrics that effectively reflect progress towards adaptation. For instance, evidence that farmers have changed their agricultural practices to include assisted natural regeneration of trees on their farmland indicates that the adaptation initiative has contributed to increases in: (i) the area of land under this practice, (ii) the agricultural productivity and production of that land, and (iii) the food security of farm households involved. This is highly significant, because assuring traceability of

biophysical outcomes from adaptation activities has been the most controversial aspect of monitoring and evaluating adaptation. Because adaptation takes place in an economic development context, adaptation metrics should not be defined in isolation from changes in farmers' behavior. Otherwise, there is a high risk of measuring development indicators rather than adaptation indicators. Knowing domains where adaptation-relevant behavioral changes have been initiated and maintained would be helpful for evaluators to trace adaptation components in development outcomes, and reduce risks of confounding adaptation and development effects.

14.4 Needs for Incorporating Behavioral Theory into Adaptation M&E Approaches

Several authors Olivier et al. (2012) and Bours et al. (2013) have recognized the need for modifying conventional M&E approaches to meet the needs of climate change adaptation programs. They advocate a greater results-orientation in climate change adaptation interventions. However, there have been minor differences between most attempts to do so and conventional interventions. This may be because designing adaptation projects and appropriate M&E systems requires robust understanding of both adaptation to climate change (Olivier et al. 2012) and behavioral theory. In fact, the differences between adaptation-related and development outcomes will depend on whether new patterns of behaviors, actions, activities and relationships have been initiated and maintained by stakeholders, including smallholder farmers, policy-makers, researchers and agricultural extension officers.

It appears important to mainstream behavioral theory into results-based monitoring and evaluation of adaptation, because adaptation comes through various domains of behavioral changes. Behavioral theory is compatible with any existing tools, frameworks and approaches used in adaptation intervention programs and the associated M&E. In addition to assisting project managers to refine existing M&E frameworks, the application of behavioral theory will contribute to strengthening communities' ownership of the biophysical changes induced by adaptation actions. Results of this research are consistent with conclusions by Gifford et al. (2011) that behavior science is crucial for confronting the complex challenges posed by climate change. Knowledge of human behavior, cognitions, and psychological adaptation can also help the integration of derived adaptation-relevant indicators with those produced by researchers in related social and natural science disciplines.

Three major conclusions can be drawn from this research. First, an adaptation process leads to behavioral changes of the beneficiaries. These changes span various domains of community life, which may go beyond adoption of technologies in the targeted sector. They may or may not be adaptation-relevant, but all must be addressed to strengthen adaptation capacities or avoid mal-adaptation. Secondly,

domains of behavioral changes can be identified before or after collecting stories of changes. These domains are useful for refining metrics of adaptation indicators.. In fact, although attributes of individual behavioral changes may vary widely, both within and among communities, they can always be located in relatively stable domains of changes. Thirdly, although claims about the generalization of changes' characteristics must be tempered by consideration of the contextual socioeconomic factors, behavioral theory can clearly add value to the existing adaptation M&E framework.

14.5 Implications for Policy, Practice and Research

14.5.1 Improving Adaptation Policy with Behavioral Theory and Models

Adaption and economic policies are subject to a number of biophysical, social and psychological influences, which future policies must consider. Thus, there are urgent needs for governments to improve the application of social research to enhance and evaluate policy, and measure longer-term trends, if adaptation policies, plans and programs are to achieve positive outcomes (i.e. enhance adaptation capacities and economic development). Behavioral change theory is one of the most promising elements of social sciences in terms of potential for improving policy outcomes. Indeed, changing individual and group behavior appears to be crucial for the effective delivery of policy outcomes, particularly in the context of climate change adaptation and mitigation. Therefore, designing adaptation policies that incorporate relevant aspects of behavioral change theory into biophysical frameworks will improve their outcomes by helping to ensure that adaptive behavior is initiated and maintained, while reversion to unhelpful behavior patterns is avoided.

14.5.2 Fitting the Human Behavior Framework into Adaptation Works

In light of the above results, current procedures for formulating and implementing adaptation options and strategies need to be revisited to tackle food insecurity more effectively in the face of climate change. To date, most adaptation programs in developing countries, from national to local, have neglected the behavior component of vulnerability analysis and adaptation action. Of course, the socioeconomic context of vulnerability is addressed together with the environmental context, but questions remain about whether current behaviors of community members are supportive of desired biophysical adaptation outcomes. There is therefore an urgent

need to consider behavioral changes when planning adaptation activities, which implies a participatory approach involving appropriate stakeholders, particularly the local communities. It also requires analysis of the current context of community members' behavior, for which knowledge of behavior theory and models is essential.

14.5.3 Strengthening Human Behavior Elements of Participatory Action Research

Participatory action research (PAR) is an approach to research in communities that strongly recognizes the importance of participation and action. It seeks to understand the world by trying to change it, collaboratively and following reflection. This approach appears consistent with research focusing on adaptation of agriculture to meet challenges posed by climate change and enhance food security. However, to increase the relevance of this approach specifically in the context of climate change, adjustment of action research aspects is required, including research designs, implementation of actions, data collection and analysis methods, reporting and learning. In the research designs it is essential to include both biophysical and behavioral components, and equal attention should be paid to activities that will influence biophysical and behavior components during implementation of the actions. The data used to evaluate success of adaptation research actions should also include biophysical and behavioral indicators, or parameters. Thus, robust conceptualization of the data collection and analysis procedures is required at the start of the participatory action research to ensure that the collected data are properly analyzed and reported, and that lessons are drawn for learning by the PAR stakeholders and other scientific communities.

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